Radio Frequency Identification

Opportunities and Challenges in Implementation

Department of Commerce
Washington D.C.
April 2005

Table of Contents

Summary

This paper provides a summary of RFID technology, the policy issues surrounding the use of the technology, and explores the technology's implications for international trade, standards, spectrum, small- to medium-sized enterprises, intellectual property rights, and economic growth. While RFID applications are being tested in both commercial and government applications in the United States, this paper focuses primarily on RFID applications, its benefits and implementation challenges for the U.S. commercial sector.

The following is a brief summary of the key points in the paper.

Technology

- RFID in the United States is poised for growth as businesses and governments explore applications implementing RFID. The large-scale adoption of RFID in commerce and security applications is likely to have important implications for businesses, government, and consumers in the United States.
- Unlike the barcode where identification is limited by line-of-sight, RFID technology and its reliance on radio waves does not require a line-of-sight for identification or a straight-line alignment between the tags and readers.
- As new applications develop, the technology will continue to evolve. Growth beyond today's user-specific systems will occur as RFID is deployed across the marketplace and the related hardware and software achieve a high degree of harmonization.

Opportunities

- As the technology matures and applications proliferate, RFID will facilitate global commerce and spur innovation and competitiveness.
- RFID technology increases visibility and accountability in the supply chain. RFID will allow manufacturers, retailers, and suppliers to efficiently collect, manage, distribute, and store information on inventory, business processes, and security controls.

Challenges

- As is common with emerging technologies, several challenges must be overcome for the technology to mature to its full potential. In the case of RFID, these challenges include: maturation of RFID technology, harmonization of standards for hardware/software and wireless spectrum operations, privacy and security concerns, and implementation cost barriers. As these technical and policy challenges are mitigated, RFID will likely become the system of choice for global commerce.

- Interoperability across various RFID systems, companies, and countries is critical to achieving wide-scale deployment of RFID technology. Development of technical standards for tags, readers, and interface systems; and allocation of operational limits for frequency and transmission power will determine global interoperability.
- Initial system and implementation costs are still being refined; in the near-term this could prove to be an impediment to large-scale adoption. Within small and medium-sized enterprises, although RFID provides them with new opportunities to compete in the global market, limited budgets, lack of in-house expertise, and a lack of access to new technologies could be an impediment for adoption.
- The collection and use of personally identifiable information through RFID technologies represents a key public policy challenge to the deployment and use of RFID technologies. Much of this concern is with the collection, use, and storage of the data rather than the technology itself. Industry-driven solutions are beginning to include a combination of operational guidelines, technical solutions, and educational campaigns.

Chapter 1: Introduction

RFID is an automated data-capture technology that can be used to electronically identify, track, and store information about groups of products, individual items, or product components. The technology consists of three key pieces: RFID tags; RFID readers; and a data collection, distribution, and management system. RFID tags are small or miniaturized computer chips programmed with information about a product or with a number that corresponds to information that is stored in a database. The tags can be located inside or on the surface of the product, item, or packing material. RFID readers are querying systems that interrogate or send signals to the tags and receive the responses. These responses can be stored within the reader for later transfer to a data collection system or instantaneously transferred to the data collection system. Lastly, data collection systems consist of computers running data processing software, which typically are networked with a larger information management system.

RFID technology is not new; it has been around since World War II (in aircraft Identification Friend or Foe systems) and in limited use in inventory management since the 1970's. The technology relies on the transfer of packets of information through radio waves or electromagnetic waves. However, it has been the exponential growth in information and communications technologies coupled with the expansion of global production and trade that has resulted in RFID technology becoming useful for managing and tracking large shipments and product sales, and as a means of identification for security purposes and supply chain management.

Market Estimates: RFID is viewed as an emerging technology with the potential to disrupt and transform currently used systems for cataloguing operations in the manufacturing, retail, and service sectors of the economy. Estimates of market size for RFID over the next 2-3 years vary significantly.

- The International Data Corporation (IDC) estimated that the RFID market for related consulting, implementation, and managed services was expected to grow 47% in 2004 and reach $2 billion worldwide by 2008.[1] IDC also reports that almost two-thirds of enterprise organizations considering RFID applications in 2004 indicated that they would rely on external resources in implementing RFID. IDC also points to future growth in the IT services and data management sectors from RFID-related implementations.
- The Wireless Data Research Group predicts that spending on RFID was about $1 billion in 2003, and will triple by 2007.[2]
- The Yankee Group estimates that RFID technology will be a $4.2 billion market by 2008.[3] A further breakdown of these estimates shows that, over the next three years,

[1] International Data Corporation, Press Release dated December 6, 2004. Accessed at http://www.idc.com.
[2] Wireless Data Research Group, Press Release dated October 1, 2003. http://www.wdrg.com/News/CurrentPR/RFID.html.

manufacturers will spend $2 billion on RFID tags and another $1-3 billion on related infrastructure.

– Another high-tech market research firm, In-Stat, estimates that worldwide revenues from RFID tags will jump from $300 million in 2004 to $2.8 billion in 2009.[4]

Although supply chain applications (inventory management and tracking) probably account for the largest dollar value driver of the technology for RFID, a survey of 450 developers around the world, conducted by Evans Data Group, suggests that RFID is currently being used more for security applications.[5] However, as the costs of RFID tags continue to fall, use of the technology for inventory control will likely increase.

Mandates by Wal-Mart, other large retailers, and the U.S. Department of Defense (DOD) requiring their top suppliers to use RFID tags on pallets and containers to track shipments have spurred the recent uptake of this technology. Both have issued RFID compliance deadlines for their suppliers. Wal-Mart expected its top 100 suppliers to tag all shipments to Wal-Mart distribution centers after January 1, 2005. DOD, which has set similar implementation deadlines, also required suppliers to tag shipments to DOD warehouses. Both mandates have phase-in timelines of two to three years from a limited number of shippers and distribution centers to all shippers, materials, and distribution centers or warehouses.

Benefits of RFID technology: The RFID system allows manufacturers, retailers, and suppliers to efficiently collect, manage, distribute, and store information on inventory, business processes, and security controls. RFID will allow: retailers to identify potential delays and shortages; grocery stores to eliminate or reduce item spoilage; toll systems to identify and collect auto tolls on roadways; suppliers to track shipments; and in the case of critical materials, RFID will allow receiving authorities to verify the security and authentication of shipped items. These uses are seen as only the beginning, and as RFID is deployed across different sectors and services, increasing efficiency and visibility, several other applications and benefits may arise.

The technology itself offers several improvements over its predecessor technologies – the barcode and magnetic stripe cards. The central data feature of RFID technology is the Electronic Product Code (EPC), which is viewed by many in the industry as the next-generation barcode or Universal Product Code (UPC). This EPC code can carry more data, than the UPC code and can be reprogrammed with new information if necessary. Like the UPC, the EPC code consists of a series of numbers that identify the manufacturer and product type. The EPC code also includes an extra set of digits to identify unique items.

---

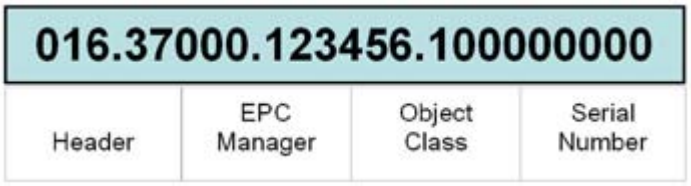
[3] "Unlocking the EPC RFID Opportunity Requires Migration Management", http://www.line56.com/articles/default.asp?articleID=5361&TopicID=3.

[4] "RFID Tags And Chips: Changing The World For Less Than The Price Of A Cup Of Coffee", (#IN0402440WT). http://www.in-stat.com.

[5] "More RFID Development in Security than Inventory Tracking", Antone Gonsalves, TechWeb News, March 4, 2004, page 1. http://www.techweb.com/wire/story/TWB20040324S0012.

Figure 1: Electronic Product Code [6]

Header: identifies the length, type, structure, version, and generation of EPC
Manager Number: identifies the company or company entity
Object Class: similar to a stock keeping unit or SKU
Serial Number: specific instance of the Object Class being tagged



RFID also allows easy and as needed uninterrupted access to data on the tag. Unlike the barcode where identification is limited by line-of-sight, RFID technology and its reliance on radio waves does not require a line-of-sight for identification nor a straight-line alignment between the tags and readers. RFID tags are also sturdier than barcodes, allowing for use in adverse conditions, and tags can be affixed or embedded on the product packaging or inside the item.

RFID System Costs: The cost of acquiring, installing, and maintaining an RFID system will be a major and determining factor in the deployment of RFID in the commercial sector. There appears to be great diversity and little quantitative information in the overall costs of acquiring, installing, supporting and maintaining an RFID system. RFID system cost is composed of tags, readers, and processing and supporting information technology hardware and software. Higher adoption rates will cause system costs to drop and encourage more RFID users.

At present, larger retailers such as Wal-Mart, Target, Albertsons, and manufacturers like Hewlett Packard, Gillette, and Proctor and Gamble, are leading the industrial deployment of RFID. According to several analysts, uptake for smaller suppliers and retailers is expected to take longer.

Current tag costs range from 25 to 40 cents per tag (higher in some cases, depending upon the type of tag), making it relatively expensive for low-end consumer items. The Auto-ID Labs (former Auto-ID Center) expects tag prices to drop to 10 cents in 2005 and 5 cents in 2006 for orders of 1 million units.[7] In 2004, Gillette placed an order for 500 million tags and was able to obtain a bulk rate of 10 cents per tag. RFID reader costs are also relatively high due to limited uptake of RFID systems. The Auto-ID Labs also expects reader costs to come down from about $250 in 2003 to about $100 in 2005 and to

[6] Electronic Product Code: http://www.EPCglobalus.org/Network/Electronic%20Product%20Code.html.
[7] SRI Consulting, "RFID Technologies", 2004.

$70 in 2006. Finally, middleware costs include computer hardware, software, data processing, data mining, personnel salaries, and personnel training. Information technology consulting firm AMR Research estimates that a consumer products company shipping 50 million cases a year could spend upwards of $20 million for RFID implementation.[8]

It is because of these associated costs that retailers currently using RFID are applying tags at the pallet or case level, rather than at the individual item level. Currently, few tags are used in the consumer marketplace, and most tags planned for introduction in the next few years are for high-value or high-cost items such as electronics, designer apparel, cosmetics, jewelry, etc. Most industry analysts predict that as RFID enters the mainstream marketplace and its volume increases, system costs will drop.

Many companies report that RFID is extremely costly to use in their supply chains. However, some suggest the initial investment will generate a large return on investment from the benefits mentioned above. Companies may also be able to reduce some costs by re-using the tags at the point of sale.

Some suggest that to generate real "economic" value from RFID, companies must look beyond inventory control and asset tracking, and use it to gather intelligence that enables them to interact better with customers and streamline processes throughout the organization. However, this could lead to other problems, such as concerns about consumer and employee privacy.

Policy Issues and RFID: RFID promises to deliver many benefits in key sectors of business, consumer, and government services. However, as is common with emerging technologies, there are challenges that must be surmounted in order for the technology to mature and realize its full potential. These challenges include: technological development, common technical and transmission standards, wireless spectrum operations, privacy and security concerns, and cost barriers especially for small-medium enterprises. As these technical and policy challenges are mitigated, RFID will likely become the system of choice for global and domestic tracking and visibility.

[8] John Goff, CFO Magazine, "Dude, Where's My Printer?", September 01, 2004, http://www.cfo.com/article.cfm/3127088/c_3148382?f=insidecfo.

Chapter 2: The Fundamentals of RFID
The Technology, its Applications, International Dimensions, and Economic Implications

In general terms, RFID represents a way of identifying objects or people using radio frequency transmissions (or using radio waves). Identification is possible by means of unique numbers identifying objects, people, and information, stored on microchips, which can be read automatically, unlike bar codes that need to be scanned manually. With recent advancements in the technology, the automatic identification data capture industry is accelerating its efforts to identify new applications to take advantage of RFID.

RFID Technology

Like information technologies (IT) over the last three decades, RFID technologies have been getting more powerful, smaller, and less expensive. A basic RFID system consists of three components:

- A tag made up of a powered or non-powered microchip with an antenna.
- A reader with an antenna that communicates with the tag sending and receiving information.
- Middleware that records and transmits the tag information to a central repository.

RFID Tags: Two types of RFID tags are in use today – passive tags and active tags. Passive tags do not have a built-in power source; they are powered by the electromagnetic field generated by the reader. Active tags are powered by an internal battery and transmit data to localized readers when they sense a reader is querying information. Tags with batteries are generally larger than tags without them, and while active tags have longer read ranges with the reader, their life is limited by the useful life of the battery. Passive tags are usually smaller and can have unlimited lifetimes. However, in comparison to active tags, passive tags have limited transmission ranges due to interference from environmental and power limits.

Most current retail applications are designed with passive tags. Active tags are currently most frequently found in defense or military operations, yet also appear in technologies such as EZ Pass, where tags are linked to a prepaid account enabling drivers to pay tolls by driving past a reader rather than stopping to pay at a tollbooth.

Another distinguishing feature of RFID tags is that they can carry more information than a bar code. Moreover, re-writeable tags, where information on the tag can be erased,

rewritten, or modified, also allow the updating of data and therefore have high utility in security and identification applications.

Table 1: Passive and Active RFID Tags[9]			
Active Tags		**Passive Tags**	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Longer read ranges	Larger size	Smaller size	Short read ranges
Self-activated in presence of a reader	Limited operational life	Long operational life	Needs higher-powered reader
Tags are write/re-write	Higher cost	Lower cost	Most read-only

Despite the increasing attention paid to RFID, technical challenges remain. While the use of radio waves obviates the needs for a clear line-of-sight placement of a pallet or item, conductive material such as metal or fluids reflect electromagnetic energy. This makes tagging metal surfaces such as metallic coffee cans and containers or shampoo bottles challenging and often results in decreased identification rates. Electromagnetic interference from other nearby transmissions can also affect the tag performance and tag to reader communications. Physical effects such as reflection and diffraction may also affect tag performance.

Inconsistent interoperability across various RFID systems, companies, and countries also presents a challenge to the wide-scale development and deployment of RFID technologies. Technical standards, frequency, and power levels are critical issues for successful global interoperability of RFID systems. There are several efforts underway to develop and refine technical standards for tags and readers, and common standards remain a goal. Likewise, differences in operational frequency ranges, allowable transmission standards, and allowable power limits in countries continue to serve as operational constraints.

With respect to current research and development (R&D) capabilities and the potential for processors fabricated with new conductive materials, some researchers envision the development of organic microprocessors for RFID tags and other applications in the future. For example, the National Institute of Standards and Technology (NIST) is looking at the technical feasibility of replacing silicon or inorganic materials in RFID devices with mostly or wholly organic materials such as plastics. This and other ongoing research in materials and tag and chip design, fabrication, and production will result in more robust and functional tags over time.

[9] SRI Consulting, "RFID Technologies", 2004; and Silicon Chip Online, "RFID Tags – How They Work"; http://www.siliconchip.com.au/cms/A_30750/article.html.

RFID Reader Technology: RFID readers perform a variety of functions: activating tags by sending querying signals, supplying power to passive tags, encoding the data signals going to the tag, and finally, decoding the data received from the tag. The reader is a handheld or fixed-mount device that emits electromagnetic waves. The power output and the radio frequency determine the range (distances) at which the tags can be read. RFID systems typically operate in frequency ranges between 30 KHz to 500 KHz (low frequency), 850 MHz to 950 MHz, and 2.4 GHz to 2.5 GHz (both considered ultra high frequency). Other frequency bands are also used for RFID applications, but these tend to be application specific, e.g., automotive electronic ignition keys, etc. Systems that run on low frequency are less costly, but have shorter reading ranges. Conversely, high frequency systems are more costly, but have faster reading speeds and longer reading ranges.

According to industry sources, there is little variability in reader design at present, but as RFID is deployed in more applications, application software will determine reader functionality. This could include: anti-collision software that prevents readers from reading more than one tag at a time; verification abilities to ensure that the reader has read all tags; interference minimizing measures between multiple transmitting readers and; security measures to prevent unauthorized access to transmitted data. An example of a promising technical development are readers developed by a U.S. start-up company that will have the capability to cut across all technology platforms. This would allow readers to be programmed to read various types of tags simultaneously, as well as process and manage the data. Technology solutions like this provide a solution for legacy and next-generation RFID technology and allow users to bypass technical incompatibility challenges.

RFID Middleware: Comprising the third component of an RFID system, RFID middleware consists of computer hardware and data processing software connected to enterprise inventory or identification management systems. A middleware platform provides the operating system, data repository, and processing algorithms that convert multiple tag inputs into visible tracking or identification data. Middleware can be managed by personnel of the company using RFID or be contracted out to an IT service provider. The primary challenges to implementing the necessary IT infrastructure and organization processes for RFID include integrating disparate systems across an organization, establishing the corporate governance that ensures the system is used properly, and ensuring interoperability with other systems. According to e-business consultants, RFID applications should be based on an open architecture that is modular, portable, scalable, and uses common data formats.[10] For example, using web-based standards can help facilitate organizational training by providing data analysis and reporting through a user interface that is simple to understand and easily accessed. To meet the growing need for middleware development, management, and maintenance functions, several leading IT companies in the United States are gearing up specific departments to handle RFID middleware systems for suppliers and retailers.

[10] Walter, Jeff, "Technology Integration", PA Manufacturer, Fall 2004.

The Future: In evaluating the potential of RFID systems, it is clear that today's RFID systems will over time evolve into highly networked communication and information transfer systems with global connectivity. However, growth beyond today's user specific systems will only occur as RFID is deployed across varying applications in the marketplace and as the tag, reader, and middleware component designs mature.

RFID Applications

The promise of RFID stems in part, from the plethora of applications envisioned by the technology developers and potential users. Applications such as: enhanced tracking in the supply chain; integration of inventory and logistics systems; automated monitoring of product availability and quality; control of critical infrastructure facilities; and improved security applications are propelling RFID to the market. While the efficiency-enhancing potential of RFID is high, there are differing time frames associated with the adoption of RFID. For the most part, current RFID tagging is at the container, case, or pallet level for inventory and shipping applications. According to one group of RFID experts, consumers will not see ubiquitous item level tagging for another five to 10 years.[11]

Commercial Applications: Simply because of the sheer scope and size of the commercial industry in the United States, many expect that over the next decade, commercial uses in all application categories will drive the maturation and deployment of RFID technology. The proposed set of applications can be divided into many categories, and include key functions such as tracking shipments and inventory, authentication, identification, monitoring sensors, payment systems, and measurement systems. Different users in similar applications might use both passive and active tags. RFID can also be viewed by its different industry sector applications, such as the consumer product industry, the food industry, the financial industry, the transportation industry, and the homeland security industry. Table 2 lists the different categories of applications and the possible time frames associated with the maturation of the technology for those applications.[12]

RFID and Supply Chain Management: Among the applications cited above, the supply chain application is likely to be the dominant RFID application in the near term. Consumer demand for lower prices is driving companies to make their supply chains more efficient. Unable to further cut the costs of back room operations, retailers are spending millions of dollars on technologies designed to extract additional savings out of their manufacturing and distribution supply chains. Some see RFID as the ultimate supply chain solution that will result in millions and possibly billions of dollars of savings throughout the supply chain and other areas.

[11] Grocery Headquarters, March 2004, v70 i3 p82 (1).
[12] This table is not intended to be comprehensive, but mostly an indicator of the breadth of applications envisioned for RFID. Additionally, the timeframes listed in the table are also notional and compiled from several sources.

Table 2 - RFID Applications		
Present to Near-term +1-2 years	**Mid-term + 3-5 years**	**Long-term + 6-10 years**
Contact-less smart cards: Access systems (subway tickets, car keys, building entry) Payment systems (car toll payment, speed pass, credit cards, library checkout)	Contact-less smart cards: Complex Financial transactions Grocery/Retail item check-out	Contact-less smart cards: Integrated entry/payment systems Bulk checkouts at retailers
Data Verification systems: Security Applications (shipping containers, port security, immigration/border control)	Data Verification systems: Implantable medical chip	Data Verification systems:
Logistics Tracking: Container Level Case/Pallet Level	Logistics Tracking: Tagging fluid-filled and metal-wrapped items	Logistics Tracking: Item Level
Anti-theft/counterfeit systems: Apparel (sewn-in-tags), tags on books, pharmaceutical products	Anti-theft/counterfeit systems: Pharmaceutical and industrial product pedigree tracking	Anti-theft/counterfeit systems:
Smart sensors: Livestock tagging Car Tire Pressure monitoring	Smart sensors: Smart store-shelves	Smart sensors: Medical diagnostics Integrated Biological, Chemical, IT sensors Smart homes

RFID technology can help suppliers eliminate delivery lag times, determine point of origin, track orders in the supply chain, and make inventories more visible (e.g., in a warehouse, in a shopping cart, on a battlefield). Technically, RFID has the capability to increase efficiencies in supply operations by minimizing the need for line-of-sight proximity between a scanner and an RFID tag. In fact, industry analysts are predicting that within a decade, RFID technology will have matured to a point where loaded shopping carts can be automatically read as a customer moves through the store checkout, without the need to unload or manually read tags.

Major retailer Wal-Mart issued a RFID mandate to its top-100 suppliers that went into effect in January 2005. Likewise, retailers Albertsons and Target have mandated that

their suppliers adopt RFID technology in the supply chain in 2005 and 2006 respectively. Within the U.S. Government, the U.S. Department of Defense (DOD) also has mandated vendors to use RFID technology in order to be able to track inventory en-route and within operational areas. According to DOD, the use of RFID tags will streamline supply-chain operations by supplying officials with electronic data that automatically locates millions of items in DOD's inventory.

In the private sector, apparel retailers also have an interest is using RFID technology to track the size, color, and type of items for inventory availability. Other potential large-scale users in the private sector are the transportation and distribution industries. Railway freight companies are interested in the ability to track rolling stock. Truck drivers want to ensure they pick up the right trailer containing the right consignment. Distribution service companies want to use RFID tags to update a central database on the maintenance schedule for their equipment. Of particular importance, companies selling hazardous products are interested in using RFID technology to ensure their tank cars and trucks containing hazardous cargo take routes that minimize risks to public safety and reduce the company's liability.

RFID technology, if combined with other sensors, may also enable a range of other applications that can exponentially increase visibility and monitoring. Companies selling bulk products, including agriculture and some chemical products, are interested in RFID to ensure that perishable products have been delivered to customers within a fixed time and under acceptable conditions. As an example, RFID technology could be combined with a temperature or shock sensor that could help determine whether a product was kept in the right temperature range or received a strong impact. Retailers selling beef are closely monitoring the cattle industry's pilot programs using RFID to track the meat's health and exposure during travels within their supply chain.

RFID is also touted as being able to help businesses reduce counterfeiting and inventory shrinkage. Because legitimate parts manufacturers are often held responsible for warranties on imitations, they are very interested in using RFID to minimize the sale of counterfeit goods. This counterfeit problem becomes more difficult when the quality of the packaging of counterfeits closely mimics that of the legitimate products, and the counterfeit products are co-mingled in shipments of legitimate products, making it difficult for legitimate distributors and retailers to distinguish the good from the bad. It also becomes particularly difficult to monitor counterfeit goods when large amounts of products are involved. Pharmaceutical companies are currently experimenting with RFID to eliminate counterfeit drugs and guarantee drug quality from the manufacturer.

Container Tracking and Security: Several companies are already experiencing great savings and increased efficiencies using this technology in their supply chains. Moreover, the use of Global Positioning System (GPS) technology, coupled with use of RFID tags, has significantly improved the movement of containers through ports. For example, the Trans Pacific Container Service used to move 7,000 containers a week through its 175-acre Los Angeles Terminal. Today, it moves 12,000 containers a week in the same amount of space as a result of implementation of a combination RFID and GPS

tracking system. Links between gate, yard and vessel operations through the terminal's computer system automatically trace a container's movement through the terminal.

Some observers have suggested that RFID could eventually allow port authorities to quickly and accurately check entire containers using RFID tags rather than spot-checking incoming shipments for hazardous or illegal goods. Containers sealed with RFID tags would permit tracking of loaded cargo containers. However, security experts are also cautioning that the use of RFID technology does not guarantee security, noting that worldwide application and detection of RFID would first be necessary to ensure security. In that regard, measures do not yet exist to prevent the unauthorized removal of an RFID tag describing a legitimate item and then the attachment of the tag to an illicit item. Any implementation of such systems would also have to overcome interoperability issues.

U.S. firms with global reach want to have worldwide interoperability for their use of RFID technologies, whether their operations are in Beijing, Bangkok, Brussels, or Boston. The Commerce Department is actively working with government officials and private sector representatives around the world to create the conditions that will allow U.S. firms to harness this emerging technology worldwide, through the harmonization of RFID frequency and other standards. Government security experts at agencies including the Department of Homeland Security (Customs and Border Patrol Agency) and the Department of Commerce are discussing the relative merits of the use of RFID for cargo and container security. The Commerce Department is also continuing efforts to address these issues through the Trans Atlantic Business Dialogue forum, and negotiations in nations such as China and Japan, are aimed at supporting the efficiency of U.S. supply chains worldwide and fostering an international environment in which U.S. firms can utilize their RFID seal solutions for improved global container security.

Government Applications: Within the U.S. federal government, many departments have initiated pilot programs to evaluate the use of RFID in specific applications. Table 3 lists various federal agencies and planned use of RFID or implementation of pilot-programs in progress. U.S. Government agencies have also come together to form the Intragovernmental Council on RFID to exchange RFID information between federal government departments and agencies, develop synergy between RFID efforts within the federal government, and expand the productive use of RFID while protecting security and privacy.

Table 3: U.S. Government RFID Applications	
Agency	**Application**
Department of Defense	Logistics support and material tracking
Department of Health and Human Services	Drug authentication, chip implants
General Services Administration	Asset management and transportation
Department of Transportation	Freight and mass transport
Department of Homeland Security	Immigration, border control, and customs (US-VISIT), search and rescue, and disaster response
Department of Veterans Administration	Patient and supply chain tracking
Department of the Treasury	Records management
U.S. Postal Service	Mail security and tracking
National Aeronautics and Space Administration	Hazardous materials management
Department of State	E-Passports
Department of the Interior	Access cards
U.S. Department of Agriculture	Animal tracking for disease control

Economic Implications of RFID

The purpose of this section is to explore the potential economic implications of greater use of RFID across the U.S. economy. This exercise is necessarily speculative because RFID is an emerging technology. Furthermore, RFID is a multi-use technology with applications that span various industries.

Economic Impact and RFID: Previous research has shown a correlation between the economy-wide productivity growth and increases in business investment in computer and communications technologies.[13] However, it is likely to be difficult to tease out the effects of a specific (and nascent) set of RFID-enabled activities on broad economic indicators, such as output or productivity growth. A recent search for RFID in a comprehensive listing of economic research in peer-reviewed journals returned no results.

Business Efficiency Improvements: Some of the emerging business applications of RFID, particularly those associated with managing inventory and supply chains, appear to promise efficiencies similar to those discussed in the context of business-to-business

[13] For a recent discussion of the relationship between information and communication technologies and U.S. productivity growth see: Dale W. Jorgenson, Mun S. Ho, and Kevin J. Stiroh, "Will the U.S. Productivity Resurgence Continue?" Current Issues in Economics and Finance, Federal Reserve Bank of New York, December 2004, Volume 10, Number 13. http://www.newyorkfed.org/research/current_issues/ci10-13/ci10-13.html.

electronic commerce. Supply chain benefits touted by RFID vendors include: real-time product tracking, decreased labor costs, security against counterfeiting, and improved accuracy in distribution.[14] These are known as operational efficiencies and are understood to result in improvements in shipping, receiving, and other handling activities. As expressed by one observer:

> Goods can be moved around faster and cheaper, as well as tracked in a more timely fashion. RFID readers require less manual labor, will be less prone to reading errors, and are faster at reading vast quantities of information than barcode and other manual methods currently used for shipping, handling and receiving. RFID tags can also make recall operations easier.[15]

Current estimates suggest that RFID will yield businesses substantial benefits in terms of inventory management, reduced loss from theft and spoilage (shrinkage), and anti-counterfeiting.

Like computers, RFID technologies may have their largest impact only after businesses have the opportunity to learn about the technology and rethink their process design using the information and capabilities made possible by RFID. As described in a recent article, integrated supply chain benefits are an example of these more complex, longer-term implications, which include:

> …greater visibility of goods, not only as they move around in one's own internal supply chain, but also as they move throughout an extended supply network of trading partners – especially downstream from a manufacturing supplier. One long-term promise of this greater visibility will be the reduction of overall supply chain inventory waste and the lack of product availability and waste caused by the Bullwhip Effect – the bane that amplifies volatility in upstream demand.[16]

Widespread use of RFID in new applications will likely take time. Pilot projects underway are revealing the complexity of incorporating RFID in existing business processes. For example, E&J Gallo winery's RFID pilot project will require the firm to consider ways to coordinate its RFID use with the operations of 480 U.S. wine and liquor distributors through which Gallo sells its wine.[17] While some companies, such as Wal-Mart as noted, are requiring their suppliers to use RFID, many of those suppliers are using a "slap and ship model" that is, they add the required RFID tag as a container or pallet leaves their facility rather than using RFID in their own supply chains.[18]

As demonstrated, RFID clearly substitutes for labor-intensive and often time consuming activities, such as collecting money at tollbooths, shipping, receiving, taking inventory,

---

[14] Manhattan Associates, "RFID: The UPC of the 21st Century," 2003.
[15] Larry Lapide, "RFID: What's In It For the Forecaster," The Journal of Business Forecasting, Summer 2004.
[16] Larry Lapide, "RFID: What's In It for the Forecaster," The Journal of Business Forecasting, Summer 2004.
[17] Laurie Sullivan, "RFID: The Plot Thickens," Information Week, January 3, 2005.
[18] Laurie Sullivan, "RFID: The Plot Thickens," Information Week, January 3, 2005.

etc. "Decreased labor costs" is often cited as a reason for businesses to invest in RFID technologies. Accordingly, some jobs will probably evolve and others will cease to exist as this technology becomes more prevalent.

If businesses deploy RFID widely in supply chains or other processes, it remains to be seen whether its contribution will be distinguishable from other business process improvements. Whether the effects of either the short-or longer-term efficiency improvements would be great enough to affect the movements of broad economic indicators, such as growth in gross domestic product, trend productivity growth, or employment also remains unknown.

Consumer Impacts: Consumers may also benefit directly from increased use of RFID. For example, if users leave their bridge/toll tags active, information from the tags can be used to determine traffic congestion. This information can be combined with other sources of information and provided to consumers in the form of real-time traffic information.[19] Enthusiasts also note direct consumer benefits from RFID tagging at the retail product level in such activities as more efficient product returns or recalls.

Size of the Industry: It is logical to expect that at least some of the firms in an "RFID industry" would in part substitute for or grow out of existing firms in the tracking and logistics business. For example, several large providers of IT services are establishing divisions or groups for RFID systems integration. However, the impact on economic growth of firms manufacturing RFID equipment or selling RFID services is difficult to determine.

Conclusion: Use of RFID is likely to increase in the near future. At present, it is unclear whether the effects of the use of RFID technology will be evident in broad measures of economic activity like output or productivity growth. Increased efficiency in activities related to monitoring the movement of objects, animals, and possibly even people is the near term benefit of this technology. As businesses gain experience with RFID, they may be able to redesign business processes to take advantage of the strengths of the technology and the information that flows from its use.

[19] For example see http://traffic.511.org.

Chapter 3: Enabling Global Use of RFID

RFID presents a potentially large commercial opportunity for equipment and software producers of the physical infrastructure (i.e., tags and readers), as well as for enterprise middleware developers for data collection and management. To maximize this opportunity in the global economy, it is important to ensure that RFID tags affixed in one country can be read easily by readers in other countries. For this to happen, technical and regulatory issues must be addressed not just at the national level but also at an international level. Regulatory issues include standards decisions and spectrum allocations. This chapter explores the status of developments surrounding three key issues relating to global RFID deployment: spectrum use, standards, and international trade.

RFID Spectrum Use

When considering interoperability for global use of RFID devices, it is first necessary to consider spectrum allocation. Perhaps the most essential aspect in worldwide acceptance of RFID is to have spectrum available in all relevant markets so that RFID can be used where needed.

U.S. Spectrum Regulation Applicable to RFID: In order to understand the spectrum issues relating to RFID, it is important to understand how these devices work. RFID devices are commonly referred to by names that indicate some characteristic of the tag or service provided by the tag. The terms: active, passive, magnetic, low or high power, low frequency, and ultra high frequency (UHF) refer to various physical characteristics of the sources of input power and/or various frequencies used by the tags, or output power of the RFID readers. In the spectrum context, the reader is more precisely referred to as an interrogator, and the tag, a transponder. In order to read the tag; the reader transmits an interrogation that is received by the tag. The tag then transmits a reply that is received by the interrogator. Both the reader and tag are intentional radiators of RF signals and therefore are regulated in every region of the globe.

RFID systems in the United States, as with other ubiquitous RF devices used by the general public, are unlicensed.[20] In the United States, RF radiation from intentional and

[20] RFID devices are permitted to operate under various sections of 47 CFR Part 15. A partial list of the more salient regulations is contained at §15.209, §15.225, §15.231, §15.240, §15.247 and §15.249 of Part 15. Regulations for operations at low frequencies (LF) (30-300 kHz) and medium frequencies (MF) (300-3000 KHz) are outlined in §15.209. RFID operations, as well as virtually any type of unlicensed operation, with certain limitations in the band 40.66-40.70 MHz and any frequency band above 70 MHz that is not within a "restricted" band, are permitted in §15.231. Operations in the band 13.110-14.010 MHz are

unintentional unlicensed radiators is regulated by the FCC under Part 15 of Title 47 of the Code of Federal Regulations (Part 15). These regulations delineate the technical specifications, such as allowable frequency, power limits, and other operational constraints, under which an intentional radiator may be operated without an individual license. Part 15 also allows operation of RFID systems over a vast range of frequencies but places limits on the allowable output power of the system.

Every available operating frequency has a specific power limit associated with it. The combination of frequency and allowable power level are the factors that dictate the functional range of the particular RFID application, whether over a range of centimeters, or hundreds of meters. These allowable power levels are particularly relevant for the power output of the readers, which have a far higher power output than the tags. In addition to power limits, there are restrictions on the use of certain bands by unlicensed devices to prevent potentially harmful interference to systems used for services such as safety, search and rescue, aeronautical communications, and scientific research. It should also be noted that unlicensed systems operating under Part 15 must accept any interference from other systems in these bands (including interference from other unlicensed devices).

International RFID Spectrum Availability: Many countries do not have rules for unlicensed systems like the United States. Instead, they allocate spectrum on a primary or secondary basis and require that all radio transmitters be licensed by the government. Also, some countries that allow RFID currently do not recognize active tags within their regulations. Similar to the United States, several other countries do not allocate spectrum specifically for RFID but to categories of service such as "short range devices." The ITU recently released a recommendation that outlines the spectrum requirements and regulatory approaches applicable to short range devices in Europe, United States, Peoples Republic of China, Japan, and South Korea.[21] Table 4 contains a partial list of countries currently using RFID and the frequency bands allowed for RFID operations.

outlined in §15.225, while section §15.240 contains regulations specifically created for RFID systems used to identify the contents of commercial shipping containers. Operations in the bands 902-928 and 2400-2483.5 MHz as well as other bands are set forth in §15.247 and §15.249. Several of the bands cited above for e.g., 902-928, and 2400-2483.5 MHz, are known as Industrial Scientific and Medical (ISM bands) and are recognized internationally.

[21] ITU-R Recommendation SM.1538-1 "Technical and operating parameters for short-range radio communication devices."

Table 4: RFID Operational Frequencies in Countries	
Frequency	**Regions/Countries**
125 –134 kHz	United States, Canada, Japan, and Europe
13.56 MHz	United States, Canada, Japan, and Europe
433.05 – 434.79 MHz	In most of Europe, United States (active tags at certain locations must be registered with the FCC), and under consideration in Japan
865 – 868 MHz	Europe
866 – 869 and 923 – 925 MHz	South Korea
902 – 928 MHz	United States
952 – 954 MHz	Japan (for passive tags starting in 2005)
2400 – 2500 and 5.725 – 5.875 GHz	United States, Canada, Europe, and Japan

There are exceptions in terms of allowable frequency and functional use of the bandwidth for critical operations both in the United States and in other countries. For example, the allowable bandwidth and power for RFID devices are not generally the same from International Telecommunications Union (ITU) region to region. In ITU Region 1, which covers most of Europe, the industrial, scientific and medical (ISM) radio band (13.553-13.567 MHz) is much narrower than the bandwidth that is allowed in the United States for RFID. Also, use of the band at 433 MHz for active RFID in the United States is intended for container tracking and is allowed at higher power levels than generally permissible for unlicensed devices in this band. However, operations of such systems are limited primarily to industrial locations, such as railheads and shipyards, and the systems must be registered with the FCC. In Europe, however, the 433.05 – 434.79 MHz band is an ISM band and is allocated on a primary basis to "short range devices" such as RFID.

Many nations in East Asia (e.g., China, Japan, and South Korea) are currently developing their own regulations for RFID. Japan is in the process of revising its regulations to allow the 950 MHz band to be used starting sometime in 2005 for unlicensed, low-power passive tag RFID systems. They are also establishing a license structure for high-power (power levels up to any level not hazardous to humans at specified distances) passive RFID systems that will be used in industrial areas.

Additionally, although some of these ISM frequency bands are internationally recognized (for e.g., 13.56 MHz and 2,450 MHz), others are not. In the United States, 915 MHz is recognized as an ISM band, while 433 MHz is not. However, in Europe the 915 MHz is not recognized, while 433 MHz is. Differences like this add to the challenges of harmonization of RFID bands.

Harmonization of RFID Frequencies: As stated earlier, it is essential to have spectrum available in all relevant markets if RFID is to work globally. While harmonized frequency bands for RFID systems are important, it is also important to have a workable authorization regime and licensing framework for each of the relevant markets when harmonization is not practicable. There could be benefits in reduced costs to harmonizing spectrum on a global basis in a small number of frequency ranges. On the other hand, using more complex hardware and software, it is technically possible for individual tags and readers to operate with multiple frequency bands within different markets. It is important to give manufacturers and operators flexibility in spectrum options, particularly for the diverse set of RFID applications.

The U.S. government looks to industry to move toward harmonization by developing industry standards through consensus, not government regulation. In instances where consensus has been achieved, the United States has modified existing regulations. Recently, the FCC modified its Part 15 Rules to more closely align, or harmonize, the regulations for operations of RFID in several bands with the European Telecommunications Standards Institute (ETSI) standards for low-power devices in Europe and Australia.[22]

In another example of harmonization, the band 13.553 – 13.567 MHz is designated internationally for ISM applications. A recent FCC rulemaking has allowed increased bandwidth and power levels specifically to accommodate RFID. The requested rule changes were to use the limits developed by the ETSI for low power devices operating in this band.[23] The new rules permit a 20 dB increase in power within portions of the band 13.110-13.410 MHz as well as operations in bands where previously no intentional radiation was permitted.

In another instance of harmonization, Part 15 regulations were modified to allow operations of RFID systems employing active tags in the frequency band 433.5 – 444.5 MHz to identify the contents of commercial shipping containers. Although this frequency range is in a band that is recognized in some regions of the world as an ISM band, this band it is not allocated for ISM in the United States. The rules in Part 15 were however, modified to allow increased power levels for tracking containers.[24]

In recognition of the complications associated with international harmonization of frequency bands, DOD requires that passive RFID systems be both multi-mode and multi-band to meet global requirements. Accordingly, DOD has issued a set of policies mandating system performance and functionality for implementing RFID systems within the DOD supply chain. Additionally, it specifies operation in the 860 – 960 MHz frequency ranges and requires that passive RFID systems be capable of operating in this

[22] See *Review of Part 15 and other Parts of the Commission's Rules*, Notice of Proposed of Rulemaking and Order, ET Docket 01-278,16 FCC Rcd 18205 (2001) ("Notice").
[23] See *Review of Part 15 and other Parts of the Commission's Rules*, Second Report and Order and Memorandum Opinion and Order, ET Docket 01-278, 18 FCC Rcd 14741 (2003).
[24] See *Review of Part 15 and other Parts of the Commission's Rules*, Third Report and Order, ET Docket 01-278, 19 FCC Rcd 7484 (2004).

frequency range.[25] The changes described above should allow manufacturers to have considerable savings by producing fewer model types of RFID systems and enhancing their ability to compete in world markets.

Standards Issues Relating to the Interoperability of RFID Systems

The promise of RFID and its potential for widespread application arise from increased cost-savings and RFID's role as a cross-sectoral enabling technology. Sound technical standards ensure the interoperability of devices and technologies and are a key factor in determining the extent of RFID deployment and its commercial impact.

Standards for RFID systems: The use of standards in RFID technology, applications development, and deployment is a multi-tiered issue. For example, standards are needed to specify performance of tags (whether passive or active) to ensure that tags meet intended designs, such as single-write/multi-read tags, multi-write/multi-read, or for potentially sensitive applications requiring a built-in disable function as in single-write/single-read tags. Standards also cover the air-interface operational requirements, i.e., the parameters for interaction between a tag and the tag reader such as transmission and receiving frequencies; algorithms by which the tag reader can communicate with the tag; and in case of active tags, when the tags would respond to a reader query. Another set of standards is required for the software that supports the readers and the tags, and for the data obtained from the tags. Likewise, standards would also cover systems for coding information contained in the RFID tags, for handling the estimated terabytes of data generated from the information contained in the tags, and for ensuring the adequate protection of data for both security and privacy concerns.

EPCglobal RFID Standards Activities: In addition to these initiatives, activities are also underway in private sector organizations such as EPCglobal Incorporated, the global consortium that manages on behalf of its members the UPC information in bar codes. EPCglobal has developed a series of specifications (version 1.0/1.1) that cover issues such as: physical placement of the tag, tag-coding structure, tag data specification, and air interface.[26] EPCglobal has recently ratified a Generation 2 specification that EPCglobal claims would allow for global interoperability of systems built to this specification. The AutoID Labs have also developed a standard (Savant) for defining how the middleware system will organize data gathered by a RFID reader and make the data available for an enterprise application.[27] In addition, within the United States, many vendors and RFID systems developers and implementers continue to develop protocols and specifications to meet the unique needs of their consumers.

---

[25] The DOD RFID policy is found at: http://www.acq.osd.mil/log/logistics_materiel_readiness/organizations/sci/rfid/rfid_policy.html.

[26] See http://www.EPCglobalinc.org/standards_technology/specifications.html.

[27] See http://www.eannet-france.org/download/nonprotege/b_outils_ean/rfid/rfid_new/WD-savant-1_0-20030911.pdf.

ISO/IEC RFID Standards Activities: Standards development activities covering the issues raised above are also underway in different fora around the world. Globally, there are approximately 120 different protocols currently in use as tag standards. In recognition of the diversity of protocols, several standards harmonization initiatives are currently underway. For example, development of RFID standards is underway in organizations such as the International Organization for Standardization (ISO)/International Electro-technical Committee (IEC). A working group under the joint ISO/IEC Committee (ISO/IEC/JTC1/SC31/WG4) has developed the 18000 series of standards (18000-1 through 18000-7), to address issues such as the "Generic Parameters for the Air Interface for Globally Accepted Frequencies" and the "Parameters for Air Interface Communications" at different operating frequencies. However the standards do not include several issues including data content, structure, and physical implementation of the tags and readers. Similarly, two other subcommittees and their working groups (ISO/IEC/JTC1/SC31WG2 and ISO TC104/SC4/WG2) are respectively developing standards on Data Structure and standards relative to Automatic Equipment Identification and intelligent container seals for freight containers.

Lastly, there are also other standards development activities in specific countries such as China that are particular to applications anticipated for use within that country (e.g., national ID cards, government security applications).

Challenges of Multiple RFID standards: A major concern with the multitude of RFID standards development activities is the possibility that standards development in these bodies may not be coordinated and could result in multiple or conflicting standards. Multiple and conflicting standards may also hinder technology development and deployment and reduce the anticipated benefits of RFID. The existence of multiple standards forces the technology application developer to choose between standards and develop applications that might work under one standard and not the other. Over time, competition and market forces may cause some of these standards to fall out of favor, resulting in significant financial liability to those invested in technology based on defunct standards.

Another concern is the inappropriate use of standards by countries or organizations that may be looking to protect internal markets and mandate certain standards for reasons other than technical merit or interoperability. Challenges may also arise from standards established to meet immediate requirements, such as reduced time to market, and short-term economical gains, that do not have the flexibility to incorporate future technological advances and developments. Other limitations to harmonizing standards may arise when organizations develop standards based solely upon the infrastructure presently available, for example RFID standards in a country using the high frequency (HF) range for RFID operations, may be very different from those required in a trading partner country that uses the ultra high frequency range (UHF) for its RFID operations.

For example, passive UHF tags operate in the 902 MHz to 928 MHz range in the United States and Canada, and in the 862 MHz to 870 MHz range in Europe. Meanwhile in Japan, passive RFID systems will operate in the 952 to 954 MHz ranges starting in 2005.

Globally, tags operating in the 433.92 MHz, 862-892 MHz, 902-928 MHz and 2.45 GHz ranges are all being used to track various sea/land containers. Differences in telecommunications laws and regulations among countries will put pressure on standards developers for the development of RFID standards consistent with local laws and regulations, possibly resulting in RFID standards that are at odds with the requirements of a trading partner country.

Thus, the successful development of RFID standards and deployment of the technology relies heavily on the cooperation and collaboration of the standards developers, whether in an international or a domestic setting, to ensure that RFID standards are based on technical merit and support interoperability.

International Trade Aspects of RFID

The use of RFID in supply-chain processes has generated a high level of national and international interest from RFID technology producers and users from businesses and governments around the world. However, the commercial benefits of RFID could be limited by technical and regulatory decisions by countries that hope to capitalize on this opportunity to the benefit of their national vendors. Most importantly, in order for RFID to work in the international arena, interoperability among RFID tags and readers is critical. Interoperability can only be achieved if tags affixed in one country are recognized by readers in other countries. If the RFID technologies employed by various countries are significantly divergent, this could become not only a significant trade barrier in RFID technology and software applications, but also inhibit one of the technology's principle uses in tracking goods through the supply chain.

To enable RFID technologies to be adopted and used globally, many international trade issues affecting the use of RFID will have to be resolved. These issues include, but are not limited to: international interoperability of tags and readers, international spectrum allocations to facilitate international operability of RFID, and issues surrounding global variations in data privacy concerns and legislation. These issues may demand U.S. Government attention to improve access to foreign markets for U.S. companies.

The U.S. Government advocates for open, market-driven approaches to standards setting and spectrum allocation, as opposed to government mandates. U.S. Government policy on technology neutrality provides that standards should not be used as obstacles to trade. Furthermore, the U.S. Government believes that spectrum allocation should allow flexibility in the choice of the technology used. For RFID technology to reach global applications and for businesses to realize economies of scale from RFID, it is critical that international and country regulatory processes remain transparent and nondiscriminatory.

Country and Region RFID Activities

China: In addition to supply chain management, China plans to utilize RFID technology in transportation, commerce, personal identification, and medical applications. There are several working groups in China addressing RFID technical standards issues. In early 2004, the Standardization Administration of China (SAC) established a National RFID Standards Working Group to draft and develop a national RFID standard and test frequency bands of 433 MHz and 915 MHz for electromagnetic interference. It is unclear whether this group will consider existing international standards or develop China-specific RFID standards, which will force foreign and domestic manufacturers to conform to this standard in order to operate in the Chinese market.

In addition, the Article Numbering Center of China (ANCC)'s Electronic Product Code (EPC Global-China) Working Group under SAC, and the China Electronics Standardization Institute's (CESI) RFID Working Group under the Ministry of Information Industry are also working on RFID issues. The ANCC represents China in the International Standards Organization Working Group dealing with the product coding aspects of RFID (ISO/IEC JCT1/SC31). While CESI realizes the importance of universal standards for successful implementation of RFID, they have voiced privacy and security concerns and the stated "unique circumstances of the China market" as justification for China-specific RFID standards. SAC's March 9, 2004 Notice 2004/008 officially suspended CESI's RFID Working Group.[28]

China's possible development of a national standard has serious implications on supply chain management for industries that rely on China as a manufacturing hub. China exported $438 billion in manufactured goods in 2003. Wal-Mart, which purchased $15 billion of Chinese-made goods in 2003 (almost 70 percent of its suppliers are in China) and is the single largest importer of Chinese-made goods, has been encouraging China to adopt EPCglobal's standards to ensure interoperability across its global supply chain.

Some experts speculate that China wants to develop its own RFID standard to avoid paying royalties on international standards and to protect their domestic IT industry. RFID companies continue to closely monitor these developments so that their technologies will not be excluded from the Chinese market.

Japan: Japan currently allows RFID operations in the 135 kHz, 13.56 MHz, and 2.45 GHz bands, consistent with the United States and the European Union. Japan has already adopted RFID for a variety of purposes, including anti-theft devices, public transportation, and supply chain management. In their 2004 white paper on the status of information and communications in Japan, the Ministry of Internal Affairs and Communications (MIC) outlined a "u-Japan" policy to promote a "ubiquitous network society."[29] The paper portrayed RFID as a key component in such ubiquitous networks, along with broadband and mobile Internet access and "intelligent home appliances."

[28] "Reorganizing China's RFID Development" http://www.usito.org/uploads/287/weekly_dec24.htm.
[29] MIC website: http://www.soumu.go.jp/joho_tsusin/eng/whitepaper.html.

In 2004, MIC established a study group to recommend technical specifications for RFID in the UHF band. Specifically, they were tasked to examine the 950 MHz band (vacated in 2003 by mobile service provider KDDI) for passive tags and the 433 MHz band for active tags. In December 2004, the MIC study group finalized its recommended specifications for passive tags in the 950 MHz band, which would also be readable at other frequencies such as the 915 MHz and 868 MHz bands.[30] Based on this report, MIC has identified the following two categories for passive tag operations:

- Passive RFID operations in the 950 MHz band with high power emissions, between 10mW (milliwatts) and 4W. In this category, in January 2005, MIC released for public comment the amendments to the ministerial ordinances of the Radio Law, drafted by the Radio Regulatory Council, that specify the technical requirements for a radio station license for RFID systems, expected to be used in factory or cargo situations.
- Passive RFID operations in the 950 MHz band with low power emission less than 10 mW. This category would apply to RFID systems using handheld readers and writers and would be license-exempt.

The MIC study group has delayed its deliberations on specifications for active tags in the 433 MHz band, due to questions about possible interference with amateur radio uses.

South Korea: The cost and limited scope of available RFID systems has made it a currently impractical choice for commercial applications in South Korea. RFID has been used in South Korea primarily for tracking livestock, public transportation fare payment, highway toll collection, and postal services.

The South Korean government is promoting RFID to satisfy growing demand for supply-side applications in South Korea and globally in hopes of becoming a leading exporter of RFID technology. South Korean electronics firms such as Samsung and LG are heavily involved in developing RFID technology. Nevertheless, South Korea's RFID technology is currently years behind that of Japan, Europe, and the United States. Recognizing this, the South Korean Ministry of Information and Communication (MIC) is promoting RFID technology investments as part of its "839 Strategy."[31] This strategy is intended to promote development of 8 Services, 3 Infrastructures, and 9 New Growth Engines.

South Korean industry has just launched a "Mobile RFID Forum" that is intended to speed the development of RFID technology in South Korea by integrating RFID with South Korea's advanced mobile communications technology. This month, five leading South Korean electronics manufacturers and mobile-phone operators established the Mobile RFID Forum to promote the use of RFID and short-range data transmission between wireless devices, and 63 other South Korean firms reportedly plan to join the forum. The forum aims to commercialize mobile-phone-based RFID services in 2007.

[30] MIC report, http://www.soumu.go.jp/joho_tsusin/eng/Releases/NewsLetter/Vol15/Vol19_20/index.html#6

[31] See http://www.mic.go.kr/eng/res/res_pub_it839.jsp

The MIC also announced in September 2004 that it would take a technology neutral approach to RFID standards, allowing both the U.S. and the European air interface standards to be used in South Korea. This position is intended to defuse controversy in South Korea because the U.S. spectrum regulations allow RFID operations over a larger portion of the spectrum (902-928 MHz), while the European standard allows less (863-870 MHz), leading some South Koreans to think the European version is more appropriate for the more tightly packed South Korean spectrum environment. The government-financed Electronics Technology Research Institute (ETRI) also favored the European standard because it is conducting joint research on it with European partners. Local industry, however, strongly favors the American standard because it is commercialized, while the European standard has yet to be approved by the European Telecom Standards Institute.

According to the South Korean trade press, MIC has acknowledged that there may be some interference problems if both standards are used simultaneously in the same frequency band. Nevertheless, MIC was reportedly expected to complete a plan for avoiding any such interoperability problems by November 2004, after consulting with the RFID Technology Analysis and Research Group (an association of related industry and research centers in Korea).

Taiwan: Despite Taiwan's experience in establishing supply chain models and the government's success in promoting e-commerce, the adoption of RFID technologies in Taiwan has been relatively slow. However, Taiwan could become very competitive in the RFID market due to its world-class silicon wafer manufacturing capabilities and its comprehensive supply chain.

The government of Taiwan is beginning to assist in the development of an RFID industry and to promote the use of RFID technologies among leading industries. The Departments of Industrial Technology (DOIT) and Commerce within the Ministry of Economic Affair (MOEA) are the two major departments promoting RFID development in Taiwan. The government announced a four-year (2004-2007) development plan to develop RFID hardware and application technologies with an average budget ranging from NT$80 million to NT$100 million (approximately $2.5-3 million) annually.

In March 2004, the MOEA helped more than 80 Taiwanese companies and the Industrial Technology Research Institute (ITRI) to form an RFID alliance to develop RFID tags, readers, and applications. The first RFID testing laboratory opened in Taiwan in late 2004, in partnership with Sun Microsystems. A study commissioned by the Taiwan government in November 2004 showed that among four leading industry sectors (manufacturing, transportation, logistics and distribution centers, and medical care), only 8 percent of enterprises have adopted RFID technologies. The study cited lack of standardized technical specifications, high prices and complicated implementation procedures as impediments to larger-scale adoption of RFID. In December 2004, MOEA formed an RFID team that includes the Science and Technology Advisory Group of the Executive Yuan, Directorate General of Customs, Chunghwa Telecom, universities, and manufacturers to help shape the industrial environment of RFID applications and

development.

European Union: Some European countries have adopted RFID technology more quickly than the U.S., largely in the retail sector. However, U.S. companies are integral partners in the majority of RFID projects in the European Union (EU). Juniper Research recently forecasted that Western European RFID revenues would exceed $1 billion by 2007.[32] Of that total, Germany and the U.K. are expected to account for approximately 40 percent. The EU government currently funds nine R&D projects for a variety of RFID-related applications. In Europe, RFID remains a technology of limited scale, with broader adoption by smaller retailers and logistics firms yet to materialize.

In early 2004, EU-based retail giants Tesco PLC (UK), Metro Group (Germany), and Carrefour Group (France) teamed with Intel Corporation to form the EPC Retail Users Group to accelerate the use of RFID and EPC technology. In January 2005, Metro, the world's third largest retailer, announced a complete RFID implementation at their largest German distribution center, utilizing tags and readers produced by U.S. company, Intermec Technology Corporation. Though still in the early stages of adoption, these retailers, and others, including Marks & Spencer, are realizing supply chain and inventory control efficiencies, as well as anti-theft protection. In addition, the UK Government is partnering with Microsoft and Intel to launch an RFID testing and evaluation center in the near future.

The European travel and transportation industries have also initiated large-scale RFID projects. In July 2003, logistics firm Crisplant Corporation began a trial at the Brussels and Stockholm airports to route and track baggage containers via RFID instead of barcodes. Escort Memory Systems from Scotts Valley, California, supplied the readers for this trial. As early as 2002, Finnish airline Finnair installed RFID-based automatic passenger boarding and check-in systems for select e-ticket passengers. Plans by the EU to integrate RFID technology in EU citizen passports have been delayed temporarily because of interference concerns caused by the introduction of multiple RFID-based biometric identifiers (in visas and in the passports). Despite these concerns, the EU remains committed to integrating RFID technologies that hold identifying biometric data in passports.

On January 19, 2005, the European Commission's Working Party of Member State Data Protection Authorities published a working document on data protection issues related to RFID technology. The document is the first formal EU position paper, and portrays RFID as being a potentially invasive technology. However, rapid adoption of RFID in some European countries may hasten discussions on RFID and privacy.

[32] Griffin, Susan and Williams, Colin; "RFID Futures in Western Europe." January 2005, Juniper Research. http://www.juniperresearch.com.

Chapter 4: Other Issues relating to RFID

In order to fully understand the effects of RFID on the commercial business sector, certain supplementary issues must be addressed. These include: the generation of intellectual property rights for RFID technologies, deployment of RFID by small and medium enterprises, and the implications of privacy and security in RFID deployments.

RFID and Intellectual Property Rights

In the development and commercialization of RFID technologies, businesses should be aware of the importance of securing, maintaining, and protecting intellectual property rights. In general, intellectual property rights in the United States include patents, trademarks, and copyrights. Trade secret law can also be used for protection by businesses developing or using RFID and sensor technologies and is considered an intellectual property right. Patents, the most relevant form of protection for RFID technologies, are discussed in the following section.

Patents: Patents are a type of intellectual property protection designed to stimulate innovation, design, and the creation of new technologies. Once a patent is issued, the patent owner has the exclusive right to make, use, sell, and import the patented invention. Patent protection lasts 20 years from the date of the filing of the patent application, except for Design Patents that have a term of 14 years from grant. The U.S. Patent and Trademark Office (USPTO) within the Department of Commerce is responsible for examining patent applications and issuing patents in all technological areas, including RFID and sensor technologies.

RFID and sensor technologies are interrelated technologies that include tags themselves and communications systems that employ interrogators and responders. Therefore, once an RFID-related patent application is received at the USPTO, it is assigned an examining unit handling this area of technology. For example, an application involving claims related to the structure of the tag itself would be assigned to an examining unit that handles Class 235 (which covers coded record sensors technology), while an application involving claims for the operation of a tag within a system would be assigned to an examining unit handling Class 340 (which covers detectable device on protected article, i.e. tag).

Like every patent application, an examiner will review the RFID-related application to determine whether the invention or process meets the five main requirements for a patent. First, the invention or process must fit into one of the general categories of patentable subject matter. Second, the invention or process must be “novel” that is, a patent will not

be granted for an invention that is already known. Third, the invention or process must be "useful." Fourth, the invention or process must be sufficiently different from known technologies ("prior art") to be "non-obvious" to a person of ordinary skill in the art at the time the invention was made. Fifth, the patentee must provide a sufficiently good description of the invention that a person of "ordinary skill in the art" would be able to make and use it.

The time and effort required to "prosecute a patent" (the process of obtaining a patent from the USPTO) varies greatly from case to case and from technology to technology. In the area of RFID and related sensor technologies, prosecution could take as little as 18 months or more than three years, depending on the backlog in the particular area in which the application is examined.

In the areas where the majority of RFID applications are examined there are currently over 240 pending applications, based on filings from January 2002 to January 2005. The areas include Class 340 (Communications: Electrical), subclasses 10.1-10.6 (interrogation response systems) and subclasses 572.1-572.9 (detectable device on protected article, e.g. tag). The number of RFID patent applications is relatively small compared to the overall annual filings of over 375,000 patent applications at the U.S. Patent and Trademark Office.

SME implementation of RFID

Current RFID developments represent both opportunities and challenges to the smaller manufacturers and other small and medium-sized enterprises (SMEs). Recent research suggests that there are growing need-based RFID implementation opportunities for SMEs throughout the health care and pharmaceutical industries.[33] Likewise, RFID awareness and readiness may well represent a valuable tool in helping smaller U.S. manufacturers compete globally in other industries as well.

Though small manufactures are a critical component of the economy, the productivity gap between large and small firms is widening. Between 1992 and 1997, productivity for large manufacturers grew by 22.6 percent versus 15.5 percent for small manufacturers.[34] As large manufacturers increase their dependence on suppliers for parts and services, the performance and capabilities of small manufacturers become even more critical to the competitiveness of all manufacturers and the health of the U.S. economy. According to a National Research Council report, "Many of these smaller firms, however, are operating far below their potential. Their use of modern manufacturing equipment, methodologies

[33] "The RFID Life Sciences Market," ABI Research (1/31/05).
[34] U.S. Census Bureau.

and management practices is inadequate to ensure that American manufacturing will be globally competitive."[35]

Barriers to SME adoption: Limited budgets, lack of in-house expertise, and lack of access to the newest technologies are but a few of the significant barriers faced by SMEs. A large obstacle to large-scale RFID implementation for SMEs is cost. The burden of the costs must be borne by the suppliers, the SMEs themselves, many of whom cannot afford to adopt new technology. Although wider use of these technologies should drive the price down, many small companies will wait until the benefits of using the technology exceed the costs of the RFID system. It is also worth noting that Original Equipment Manufacturers (OEMs) that sit atop supply chains rarely provide financial assistance for that adoption.

Another barrier to widespread use of RFID by SMEs is a lack of information on systems, databases, and business processes needed to take full advantage of RFID implementations. Most inventory systems used by SMEs are based on barcodes. If existing barcode systems are working, there is little incentive to shift to a new technology. Furthermore, the business case for RFID has not yet been defined, either in OEMs or among their smaller suppliers. It is likely that most companies will have to do a full-scale business case in order to understand the return on investment and then plan for RFID implementation. Even then, a SME might face implementation challenges with its pilot program or actual implementation.

SMEs also need to surmount the complexity barrier of RFID. Many entrants that are newly thrust into RFID technology assessments and selections view RFID as primarily consisting of only tags and readers. However, the full scope of technologies often needed to implement RFID, either on the shop floor or throughout a supply chain, is wider and more complex. In addition to tags and readers, SMEs need to consider appropriate sensors, computers, middleware, database systems, enterprise applications, business processes, networking, and business process management tools to fully implement RFID.

Opportunities from Adoption: The SMEs that quickly adapt RFID technology will hold a key advantage over slower suppliers. This new and enabling technology will likely determine the overall success or failure of many SMEs in relevant supply chains. The smaller manufacturers that succeed today and in the future are agile and responsive to customer needs, whether those needs are market-driven or supplier requirements. Recent and ongoing research suggests these firms, as well as firms that follow other innovation-based practices that benefit value chains, are among those best positioned to succeed in the global marketplace.[36]

---

[35] "Learning to Change: Opportunities to Improve the Performance of Smaller Manufacturers, Committee to Assess the Barriers and Opportunities to Improve Manufacturing at Small and Medium-Sized Companies," Commission on Engineering and Technical Systems, National Research Council (1993).
[36] "Successful Strategies for Competing in a Low Cost Manufacturing World," 360vu Research and Education Foundation (2004).

For most SMEs, RFID technology will likely only be adopted if their customers mandate its use. This has been the case with other technologies and process improvements that have boosted the productivity of SMEs in the past, such as the ISO 9000 quality standard and related QS 9000 automotive industry standard, as well as the adoption of Enterprise Resource Planning (ERP) systems.

For now, OEMs and companies that manage extensive inventory are primarily the ones implementing RFID. RFID is especially popular in manufacturing industries that have regulations focused on product traceability. However, success stories among smaller firms that have adopted RFID are emerging. There is an example of a small contract electrical and electro-mechanical fabricator, producing for the military and commercial aerospace market that became RFID compliant. After going through a RFID evaluation process, the firm realized that it could use RFID to improve its shop floor management and business processes. As a result of the RFID implementation, the firm has been able to move to real-time inventory control, and can now better track work-in-progress as well as shipped goods.

RFID and Privacy and Security

A key public policy challenge in the use and deployment of RFID relates to the privacy and security of collected personally identifiable information. Many state that concerns about the capabilities and use of RFID products and networks could become a major factor in shaping deployment and consumer acceptance.

Most privacy and security concerns about RFID involve the use of RFID at the individual customer level, at or after the point of sale, rather than in supply and inventory tracking applications. Privacy concerns revolve around whether and what notice is given to customers when RFID is used; whether options are provided to customers to disable the tag; what data is collected and how it is used or shared; and how long and for what purpose the data is retained.

According to James Lewis at the Center for Strategic and International Studies, much of the concern over RFID is about the acceptable use of data, not the technology. He states that,

> "…core issues (with RFID) involve data use and data protection. RFID generates new data that can be collected, processed and shared. When this data concern boxes, pallets or containers there are clear economic and security benefits and few privacy concerns. As RFID pushes down to the tagging of individual items or of individuals, concerns over deployment and use will increase."[37]

[37] Statement attributed to James Lewis at the Center for Strategic and International Studies, Washington D.C. January 2005.

Concerns have been publicly expressed about the government's use of RFID, particularly in homeland security applications. Applications of the technology, such as in immigration and border controls efforts, or the recent Federal Drug Administration approval for human-implanted chips, have been cited as examples of "big brother watching," and have generated some public concern. However, it has been observed that in today's public debate on RFID, applications such as; auto toll payment systems, container tracking, grocery and retail store implementations are all being treated as having similar privacy and security implications for businesses and consumers.

Privacy Guidelines: RFID technology allows businesses to use technology to better understand critical business processes by creating opportunities for collecting and analyzing business-relevant information. However, such data collections can also impact the accessibility of personal information. As RFID enters mainstream deployment, it is critical to maintain a balance between the utility of the technology and the privacy protections relating to the use, collection, and disclosure of personal information. An educational and informative dialogue from the beginning is imperative to achieving this balance.

Security Issues: Data security with RFID can currently be compromised by direct interceptions of RFID transmissions or by indirect access to networks where transaction data is stored. Typically, when RFID readers query tags in their vicinity, the information collected by the readers regarding the location, status, or condition of the item or product to which the tag is affixed is relayed or transferred to a data collection system. Security concerns may accordingly arise regarding the compromise of data during wireless transmissions, the storage of the data, and the physical security of the data storage site. It is worth noting that security vulnerabilities at the database level are not RFID-specific and could apply to any application where datasets are collected and stored, such as credit card or loyalty program information.

Currently, ways exist to mitigate the unauthorized interception of RFID transmissions, otherwise known as "skimming", and include: encrypting critical data transfers, blocking data transmissions through jamming, and employing varying querying protocols used by the RFID readers. Another solution offered by RFID developers includes the option of using a "kill", "blocker", or "disabling" tag technique. These tags have the capability of either having their memory erased after being scanned for a transaction or can be re-programmed with useless information once the transaction is complete.

Possible Privacy Solutions: The general population is becoming more familiar with RFID technology, its applications, and with the associated privacy and security issues. Studies conducted in 2004 confirmed an increasing awareness among consumers about RFID technology and its uses. A recent study found that while 72 percent of the respondents had never heard of RFID, of the 28 percent that had, most had learned about RFID from the Internet versus traditional mass media.[38] Another study done by Capgemini Ernst & Young for the National Retail Federation finds that 23 percent of consumers are aware of the technology and of this 69 percent are concerned about how retailers will use

[38] Bigresearch and Artafact study. http://www.bigresearch.com/rfid.html, September 2004.

information stored in the tags and 65 percent are afraid of being tracked down based on their purchases.[39]

One generally accepted principle of information privacy deals with the disclosure of how information collected and stored will be used and protected. Many companies have stated that they believe that RFID privacy and security safeguards must be enabling rather than disabling. This position is based on a belief that privacy and security safeguards must be market-based solutions that balance the evolving nature of RFID technology against the need for controlled sharing of information. Representing a consumer perspective, there is a belief that most consumers prefer notifications of use and consumer choice in information use or sharing. To address these concerns, many companies are currently working on finding ways to resolve privacy issues. These solutions – many of which are still in development – take the form of proposed operational guidelines, technical solutions, and educational campaigns.

Industry Guidelines: EPCglobal, a membership organization working with industry partners to establish global standards regarding the development, implementation and adoption of the EPC and RFID technology has stated that in order to unlock the potential of RFID and the EPC, it is important to address privacy concerns regarding the use of the technology. EPCglobal has proposed a set of privacy guidelines that companies deploying RFID can follow to complement existing national and international legislation and regulation dealing with consumer protection, consumer privacy, and other issues.[40] Key tenets of the guidelines incorporate principles of industry responsibility, providing accurate information to consumers, and ensuring consumer choice. The guidelines encompass practices for consumer notice; consumer choice; consumer education; and record use, retention, and security. EPCglobal also suggests that companies provide consumers with notice and choice when tags are used, including options to disable tags after the point-of-sale.

Technical Solutions: These range from completely disabling tags at the point-of-sale to re-writing tags with meaningless information. One option, kill codes, allows for an item's RFID tag to be permanently disabled at the point of purchase. Germany's Metro stores are demonstrating this concept at their pilot store in Dusseldorf. Once a customer has paid for a product, they can choose to deactivate the RFID tag. The RFID De-Activator allows the consumer to overwrite the EPC tag information with zeros.[41] Other technologies such as RSA Security's Blocker Tag prevent an RFID tag from being scanned by unauthorized readers.[42] The blocker tag allows for items to be scanned normally for inventory purpose, but once the item is purchased, the "blocking feature" does not allow the RFID tags to be scanned by unauthorized readers. In addition to

[39] Grocery Headquarters, March 2004, v70 i3 p82 (1).
[40] EPCglobal Privacy Guidelines, "Guidelines on EPC for Consumer Products", http://www.EPCglobalinc.org/public_policy/public_policy.html
[41] Presentation at the Department of Commerce, Washington D.C., "Data Privacy Initiative @ SAP" by Dr. Christoph Lessmoellmann, and Thomas Riehmer, SAP. January 26, 2005.
[42] A. Juels, et. al. "The Blocker Tag: Selective Blocking of RFID Tags for Consumer Privacy." In V. Atluri, ed. 8th ACM Conference on Computer and Communications Security, pp. 103-111. ACM Press. 2003. http://www.rsasecurity.com/rsalabs/node.asp?id=2060.

ensuring the security of individual tags and readers, the protection of RFID systems through the proper authentication, encryption, and database security is critical to any RFID implementation plan.

Education: Education and outreach to consumers explaining the technology, the choices, and the benefits is recognized as being just as important as the other solutions being proposed. As part of the education process, information sharing of best practices at the business-level regarding data collection, data-uses, and data-sharing, etc. would conceivably allow for the emergence of industry developed standards of acceptable and informed procedures.

As an example, the Federal Trade Commission held a hearing in June 2004 to "facilitate discussion of the public policy issues surrounding the use of RFID and to encourage the development of best practices for RFID that do not compromise consumers' privacy and security."[43] Their recently released report finds that the privacy issues associated with RFID are linked to database security, and that industry can play an important role in addressing privacy concerns raised by some RFID applications. The report emphasizes the importance of industry self-regulatory programs, meaningful accountability provisions to help ensure compliance, and implementation of reasonable and appropriate measures to protect data collected by RFID systems.

RFID-related Legislation: Legislators in several states, recognizing privacy concerns stemming from the use of RFID have introduced bills that seek to respond to the increasingly rapid adoption of RFID technology.[44]

- Maryland, Utah, and Virginia have introduced bills designed to study the issue in more depth and to provide recommendations for future legislation.
- Missouri and Utah have introduced legislation that would require all products containing RFID tags, to be appropriately labeled.
- Utah has introduced another bill that requires instructions to be provided on how to disable the RFID tag, or a notice that the tag will remain active after purchase.
- New York, Virginia and Washington also have introduced bills that make personally identifiable information collected by automatic toll systems (like EZ-Pass) confidential.
- In California, proposed legislation regulating the use of RFID technology required businesses using RFID systems to 1) tell customers it is using an RFID system, 2) get express consent before collecting information, and 3) detach or destroy RFID tags attached to products before customers leave the store.[45] A new bill in California prohibits driver's licenses and other identity documents issued by the state from containing RFID tags.[46]

---

[43] FTC, Public Workshop: Radio Frequency Identification: Applications and Implications for Consumers". http://www.ftc.gov/opa/2004/04/rfidworkshop.htm, FTC report http://www.ftc.gov/opa/2005/03/rfidrpt.htm

[44] National Conference of State Legislatures. May 2004. State Legislatures Address Use of RFID Technology. http://www.ncsl.org/standcomm/sctech/NCSL-RFID.htm.

[45] Information Week, March 25, 2004.

[46] Jeffrey Silva, "California bill to Prohibit RFID for ID Documents." RCR Wireless News. March 1, 2005.

While none of the proposed pieces of legislation has been passed into law, the introduction of these bills signifies that RFID-related technologies appears to be generating concerns within the legislative branches of state and federal governments. According to some, legislation restricting RFID use at this early stage would likely stifle the technology and delay deployment in the marketplace. It would be more productive to monitor the technology over the next few years, while engaging with the business and government sectors regarding their respective use of RFID and their policies on maintaining RFID privacy and security.[47] The Competitive Enterprise Institute (a non-profit public policy organization advocating non-regulatory, market-based solutions) states that as RFID technology comes into full use, various social forces would constrain it more suitably than government regulation.[48]

International Privacy: A number of governments around the world, citing a need to ensure the protection of individual privacy rights, have raised concerns that the collection, storage, transfer, and use of personal information through RFID technology could possibly violate individuals' privacy rights. For example, in the European Union, the EU Article 29 Working Party of Member State Data Protection Authority has recently expressed its concern that RFID technology may contravene the requirements of the EU Directive on Data Protection. Accordingly, in recent months, the European Commission has held a number of workshops and issued inquiries concerning the privacy implications of RFID. The Asia-Pacific Economic Cooperation forum (APEC) is considering the relationship of RFID privacy to its recent privacy guidelines. In particular, South Korea has called for the development of RFID privacy guidelines in the forum's Electronic Commerce Steering Group. In 2004, Japan also issued privacy guidelines for RFID. Finally, the Organization for Economic Cooperation and Development's (OECD) Working Party on Information Security and Privacy, is currently reviewing the scope of policies and concerns with the global use of RFID on security.

[47] Julie Hutto and Robert D. Atkinson, Progressive Policy Institute, "Radio Frequency Identification: Little Devices Making Big Waves." Policy Report, October 6, 2004.
[48] Jim Harper, Competitive Enterprise Institute, "RFID Tags and Privacy: How Bar-Codes-On-Steroids Are Really a 98-Lb. Weakling," June 21, 2004, No. 89, Washington DC.

Acknowledgements

The Department of Commerce's RFID Working Group developed this paper.

The group included almost 40 representatives from the following agencies: Economics and Statistics Administration, International Trade Administration, National Telecommunications and Information Administration, Technology Administration, and the U.S. Patent and Trademark Office.

Agency contacts:

Economics and Statistics Administration
Sabrina Montes, sabrina.montes@esa.doc.gov

International Trade Administration
Linda Astor, linda_astor@ita.doc.gov

National Telecommunications and Information Administration
Tracey Rhoades, trhoades@ntia.doc.gov

Technology Administration
Dan Caprio, dan.caprio@technology.gov
Carmina Londono, carmina.londono@nist.gov
Sujata Millick, sujata.millick@technology.gov
Ben Vickery, ben.vickery@nist.gov

U.S. Patent and Trademark Office
Jin Ng, jin.ng@uspto.gov